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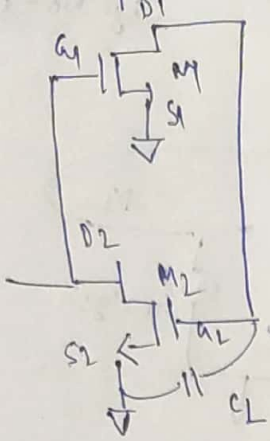
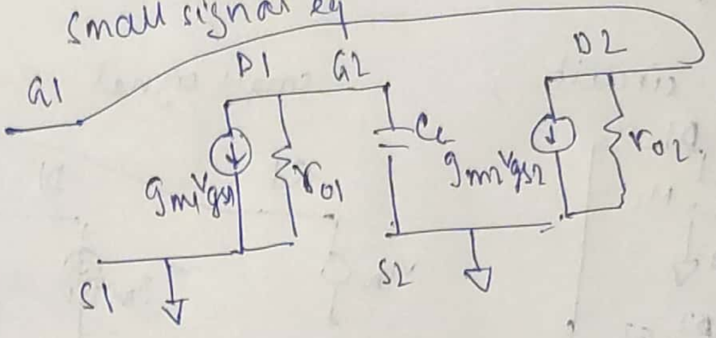
2. ii)

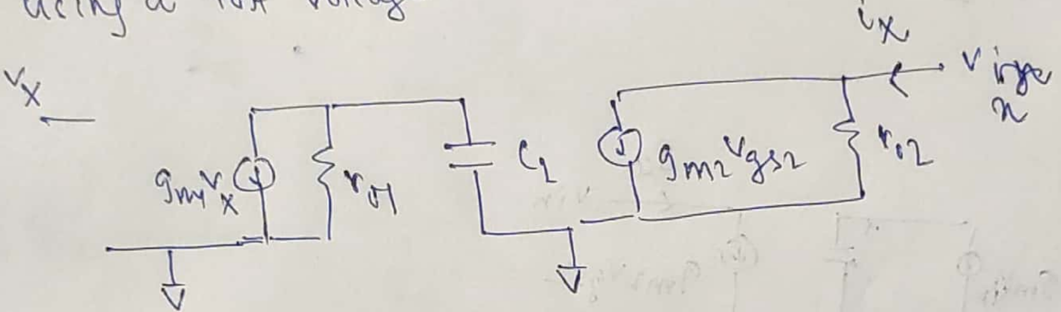
AC equivalent circuit



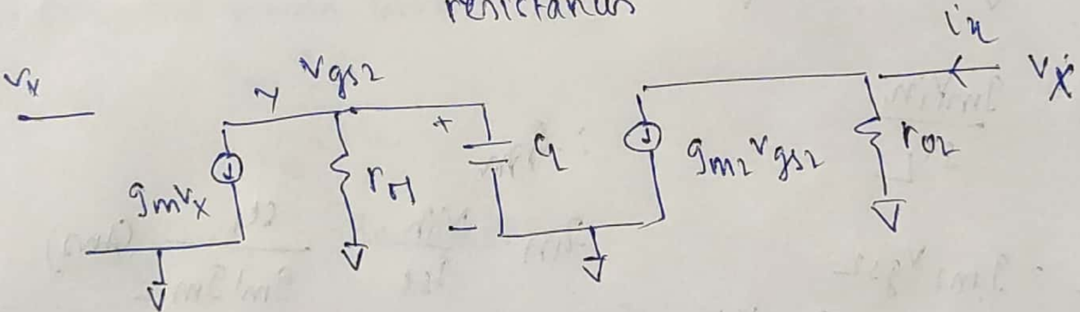
Small signal eq



Using a test voltage



or grounding all resistances



$$i_x = \frac{v_x}{r_{02}} + g_{m2}v_{gs2}$$

Applying KCL at node Y

$$\frac{v_{gs2}}{r_{01}} + v_{gs2} sC_L + g_{m1}v_x = 0$$

or $v_{gs2}\left(\frac{1}{r_{01}} + sC_L\right) = -g_{m1}v_x$

or $v_{gs2} = \dfrac{-g_{m1}v_x}{\frac{1}{r_{01}} + sC_L}$

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$$i_x = \frac{v_x}{r_{o2}} + g_{m2} v_{gs2}$$

$$\text{or } i_x = \frac{v_x}{r_{o2}} + g_{m2}\left(\frac{-g_{m1} v_x}{\frac{1}{r_{o1}} + sC_L}\right)$$

$$\text{or } i_x = \frac{v_x}{r_{o2}} - \frac{g_{m1} g_{m2} v_x}{\frac{1}{r_{o1}} + sC_L}$$

$$\text{or } \frac{i_x}{v_x} = \frac{1}{r_{o2}} - \frac{g_{m1} g_{m2}}{\frac{1}{r_{o1}} + sC_L}$$

$$\text{or } \frac{1}{Z_{in}} = \frac{1}{r_{o2}} - \frac{g_{m1} g_{m2}}{\frac{1}{r_{o1}} + sC_L}$$

For poles we would want $Z_{in} = \infty$ or $\frac{1}{Z_{in}} = 0$

$$\therefore \frac{1}{r_{o2}} = \frac{g_{m1} g_{m2}}{\frac{1}{r_{o1}} + sC_L}$$

$$\text{or } \frac{1}{r_{o1}} + sC_L = g_{m1} g_{m2} r_{o2}$$

$$\text{or } sC_L = \left(g_{m1} g_{m2} r_{o2} - \frac{1}{r_{o1}}\right)$$

$$\text{or } s = \frac{g_{m1} g_{m2} r_{o2} - \frac{1}{r_{o1}}}{C_L}$$

$$\text{or } |\omega_{p1}| = \frac{g_{m1} g_{m2} r_{o2} - \frac{1}{r_{o1}}}{C_L}$$

For zeros we would want $Z_{in} = 0$ or $\frac{1}{Z_{in}} = \infty$

$\cancel{\frac{1}{Z_{in}}}$ since $\frac{1}{r_{o2}}$ is finite

$$\frac{g_{m1} g_{m2}}{\frac{1}{r_{o1}} + sC_L} \longrightarrow \infty$$

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This implies that

$$\frac{1}{r_{o1}} + sC_L = 0$$

$$\text{or } sC_L = -\frac{1}{r_{o1}}$$

$$\text{or } s = -\frac{1}{r_{o1}C_L}$$

$$\text{or } |\omega_z| = \frac{1}{r_{o1}C_L}$$

Thus we obtain

$$|\omega_p| = \frac{1}{C_L}\left(g_{m1}g_{m2}r_{o2} - \frac{1}{r_{o1}}\right)$$

$$|\omega_z| = \frac{1}{r_{o1}C_L}$$